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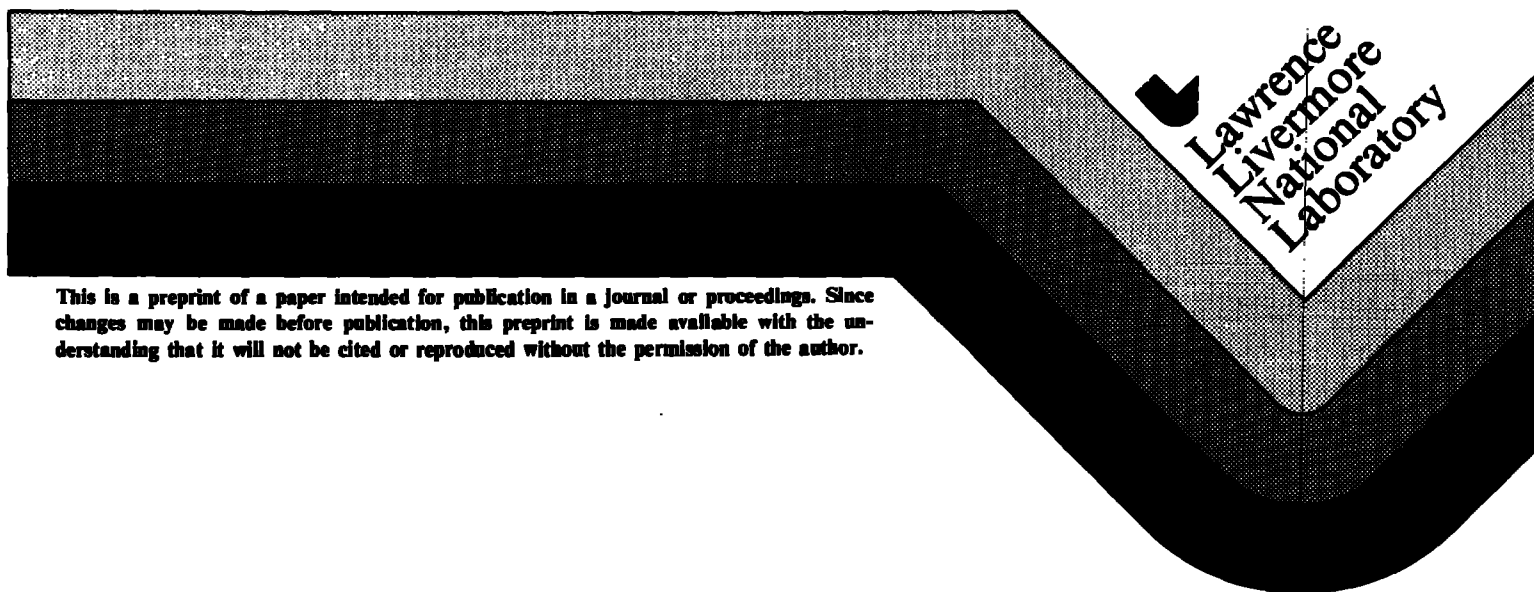
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G. E. Phillips, M. S. Singh

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## **A Neutron Streak Tube\***

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### **Abstract**

We present the design and construction of a simple neutron streak tube. The cathode is a 10  $\mu\text{m}$  thick  $\text{U}^{238}$  strip, 25 mm wide and 1.5 mm high, vacuum deposited on a stainless steel substrate which replaces the cathode of a Lawrence Livermore National Laboratory (LLNL) Model 3 x-ray streak camera. Accompanying a fission fragment, about 200 low energy secondary electrons are emitted from the cathode.

The streak tube was tested at a rotating target neutron source and at the Nova laser which produced  $10^{13}$  neutrons from the fusion target. Preliminary results are presented.

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## Introduction

In laser fusion, the D-T reaction is expected to be complete in about 100 ps. In order to study the reaction rate and the fusion dynamics, we designed a neutron streak tube of relatively high sensitivity and 16 ps time resolution.<sup>1</sup> In this paper we describe the design and construction of a simpler version and present some preliminary results of the tests at a rotating target neutron source and at the Nova Laser Fusion Facility.

### I. Neutron Cathode

A neutron cathode responds to neutrons as a photocathode responds to photons. Fig. 1 illustrates the mechanism of secondary electron generation from a neutron cathode. We choose  $U^{238}$  as the cathode material because it is easy to handle and has a large fission cross section (1.1 barns for 14 MeV neutrons). The highly charged fission fragment drags out a large number (~200) of low energy secondary electrons at the surface. Differentiating the data of Jamerson, et. al.,<sup>2</sup> we have plotted the energy distribution of the secondary electrons in Fig. 2. Such a distribution is similar to the secondary electron energy distributions from x-ray excited photocathodes which peak at about 1 to 2 eV, have full widths at half-maximum ranging from 3.8 to 6.8 eV and have comparable high energy tails.<sup>3</sup> Thus, the time resolution of the neutron streak tube is expected to be comparable to that of an x-ray streak tube. Indeed such an expectation is born out by the data of Niki, et. al., showing a time resolution of ~15 ps.<sup>4</sup>

The optimum thickness of the U cathode is ~10  $\mu\text{m}$ , the range of the fission fragments. This should give good detection efficiency

without affecting the time resolution, since all secondary electrons are emitted on or near the surface and the traversing time of the fission fragment in the cathode is small.

## II. A Neutron Streak Tube

We have constructed a simple neutron streak tube by replacing the cathode of a Lawrence Livermore National Laboratory Model 3 x-ray streak camera<sup>5</sup> with a  $U^{238}$  strip 10  $\mu$ m thick, 25 mm wide and 1.5 mm high, vacuum deposited on a stainless steel substrate. A schematic drawing is shown in Fig. 3. It has been shown that by a large vertical demagnification, an optical cathode as high as 1.5 mm can be used to increase the detection efficiency without degrading the streak camera time resolution.<sup>6</sup>

To cope with the Doppler broadening of neutron velocity at high ion temperatures ( $\sim 4$  KeV), the U cathode has to be placed as close as practical to the fusion target. As an illustration of the sensitivity of the streak tube, if our U cathode were placed at 5 cm from the target 1000 fission events would be detected for  $2 \cdot 10^{10}$  neutrons generated isotropically from the target.

## III. Static and Dynamic Tests

We have carried out a static test of our neutron streak tube at a rotating target 14 MeV neutron source of our Laboratory. The streak tube without sweeping voltage was placed at 1.4 m from the neutron source. Fig. 4 shows the static image recorded with a 15 second exposure, amounting to  $\sim 10^{11}$  neutrons generated at the target. The image is

attributed to the U cathode of the streak tube. As is seen in Fig. 4, heavy background was observed even though improvements were attained with the paraffin shield. (See Fig. 3).

We were able to carry out one shot of static test at the Nova laser soon after the fusion target started to produce  $10^{13}$  neutrons.<sup>7</sup> The neutron streak tube was placed outside a target-chamber window 284 cm from the fusion target. A static image similar to Fig. 4 was observed. A second streak tube similar to the neutron streak tube but without the U strip was placed by the neutron streak tube. The absence of the static image confirmed that the observed image in the other tube is indeed due to neutrons interacting with the U strip. In order to study the origin of the background we had placed an opaque filter behind a part of the phosphor (see Fig. 3) in the second tube. The disappearance of the heavy background due to the presence of the filter indicates that the backgrounds originate from the phosphor.

At Nova we were able to do two shots of dynamic test of the neutron streak tube. The first shot was mistimed. In the second shot, we have observed a reasonable indication of a streaked image of the U cathode. However, the quality of the picture is still poor, suggesting the need of system optimization in the future.

In conclusion, with our preliminary results and the results of Niki, et. al.<sup>4</sup>, it is reasonable to expect the neutron streak tube to be operational with some more efforts. However, it will be a nontrivial task to place the device as close as 5 cm from the fusion target.

## References

1. C. L. Wang, R. Kalibjian, M. S. Singh, SPIE, 384, 278 (1982).  
C. L. Wang, R. Kalibjian, M. S. Singh, J. D. Wiedwald, D. E. Campbell, E. M. Campbell, M. D. Cable, W. R. Graves, S. M. Lane, R. A. Lerche, R. H. Price, D. G. Stearns, S. G. Prussin, G. A. Mourou, Rev. Sci. Instrum. 56, 1096 (1985).
2. F. E. Jamerson, C. B. Leffert, D. B. Rees, J. Appl. Phys. 36, 355 (1965).
3. B. L. Henke, J. A. Smith, D. T. Attwood, J. Appl. Phys., 48, 1852 (1977).
4. H. Niki, K. Itoga, N. Miyanaga, M. Yamanaka, T. Yamanaka, C. Yamanaka, T. Iida, A. Takahashi, K. Sumita, K. Kinoshita, Y. Takiguchi, I. Hayashi, K. Oba, elsewhere in these proceedings.
5. H. Medeckí, Lawrence Livermore National Laboratory Report UCRL-89430, 1985(unpublished).
6. R. A. Lerche, H. Medeckí, G. E. Phillips, S. W. Thomas, Lawrence Livermore National Laboratory Report UCRL-86019, 1981 (unpublished).
7. S. M. Lane, M. D. Cable, S. G. Prussin, S. G. Glendinning, D. H. Munro, S. P. Hatchett, K. G. Estabrook, L. J. Suter, M. C. Richardson, P. W. McKenty, D. Roback, C. P. Verdon, elsewhere in these proceedings.

**Figure Captions**

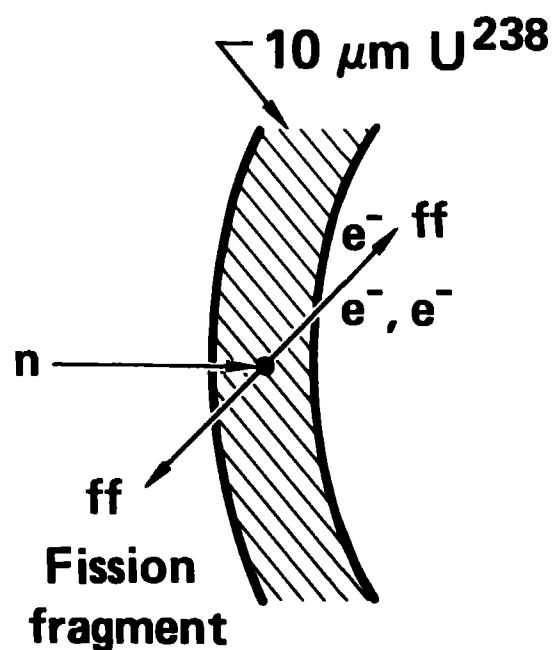
- 1. The Neutron Cathode, Illustrating the Mechanism of Secondary Electron Generation**
- 2. Energy Distribution of Secondary Electrons Accompanying Fission Fragments from U Cathode**
- 3. A Schematic Drawing of a Simple Neutron Streak Tube**
- 4. A Static Image Recorded by the Neutron Streak Tube at a Rotating Target Neutron Source**

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## Neutron cathode — mechanism of secondary electron generation



Each fission fragment, ff, drags out 400-200 secondary electrons, all of low energy  $<20$  eV

# Secondary electron energy distribution from fission fragments



(Derived from data of Jamerson et al.  
J. App. Phys. 36 355 (1965))

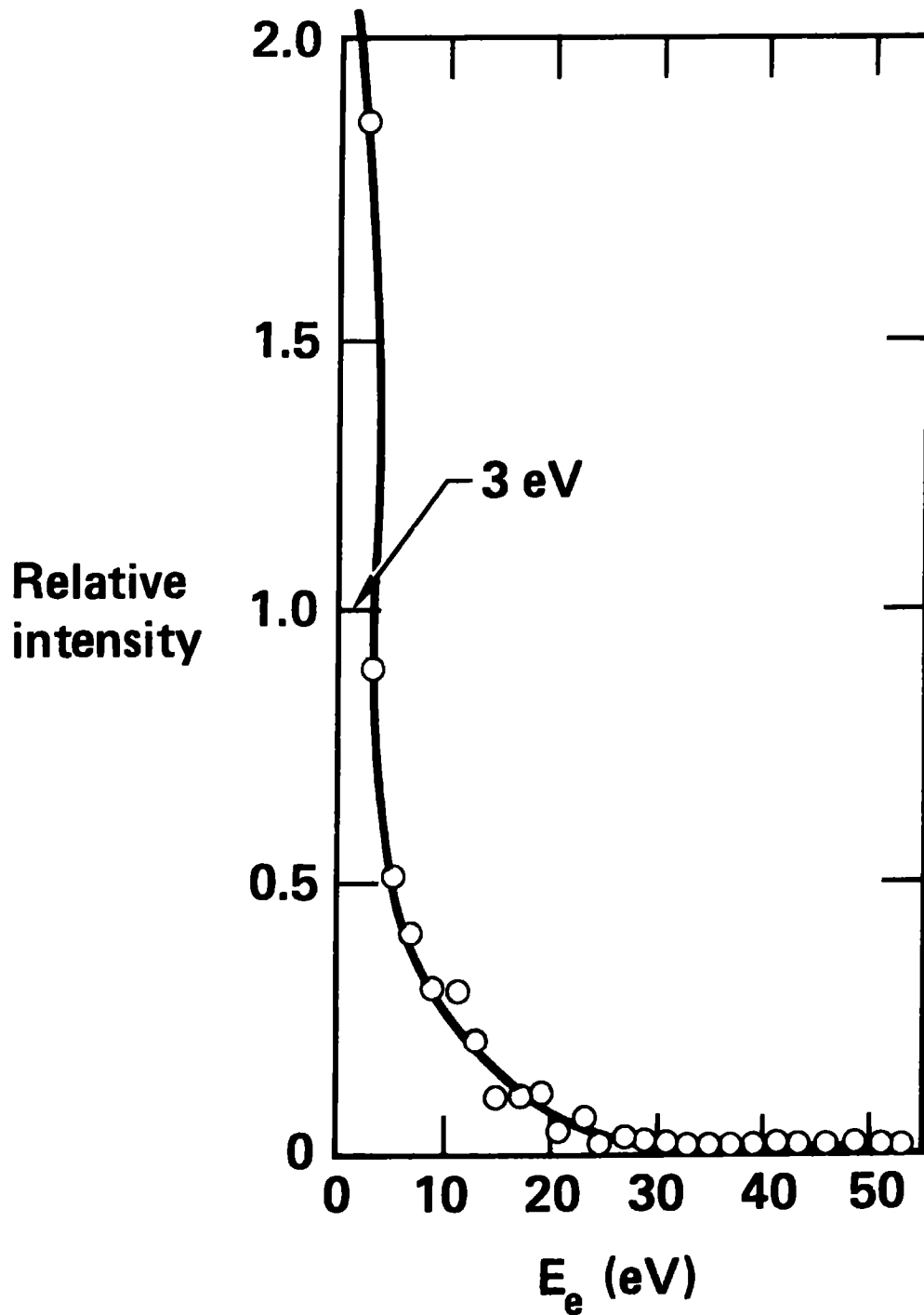


Fig. 2

# A neutron streak camera

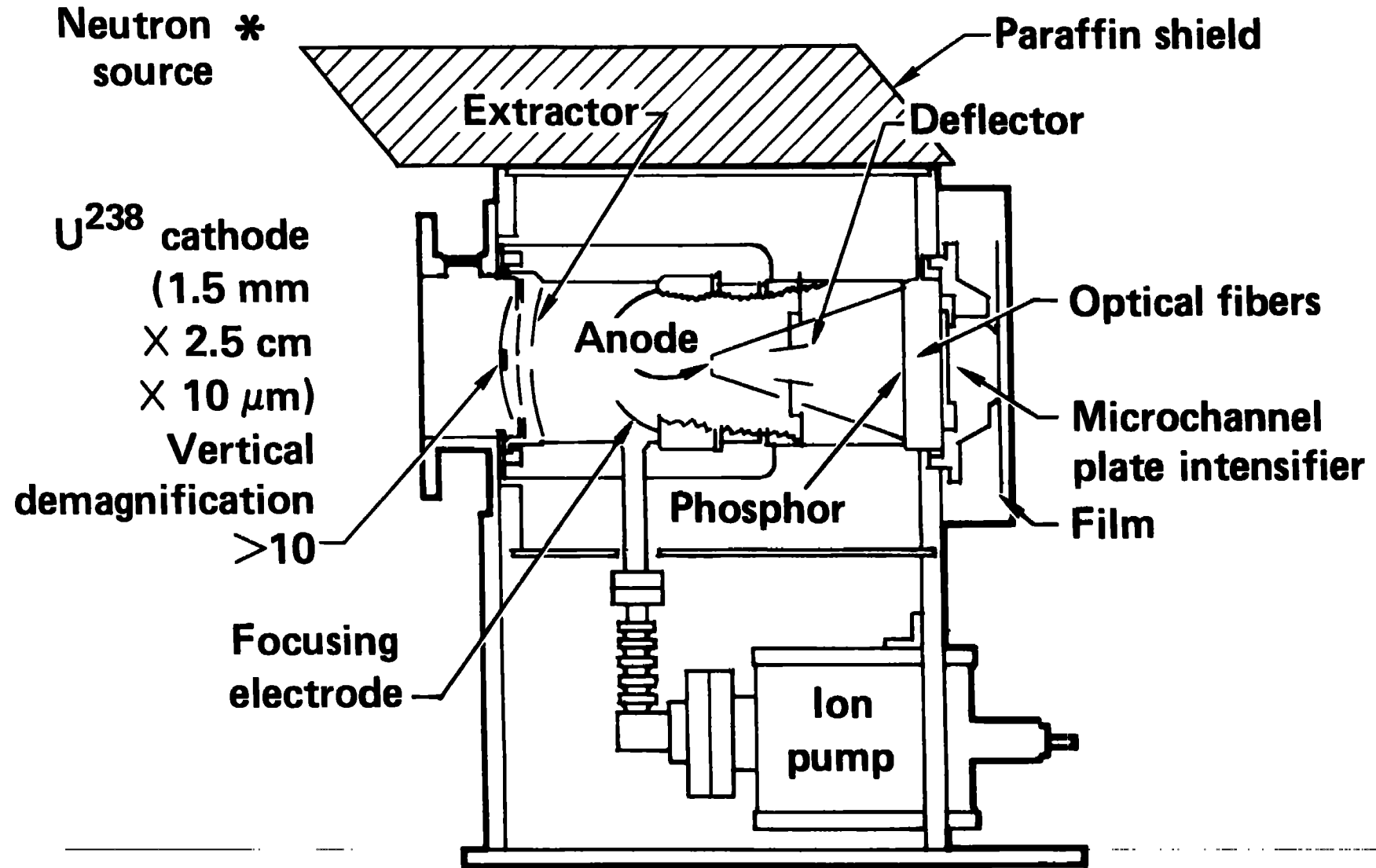
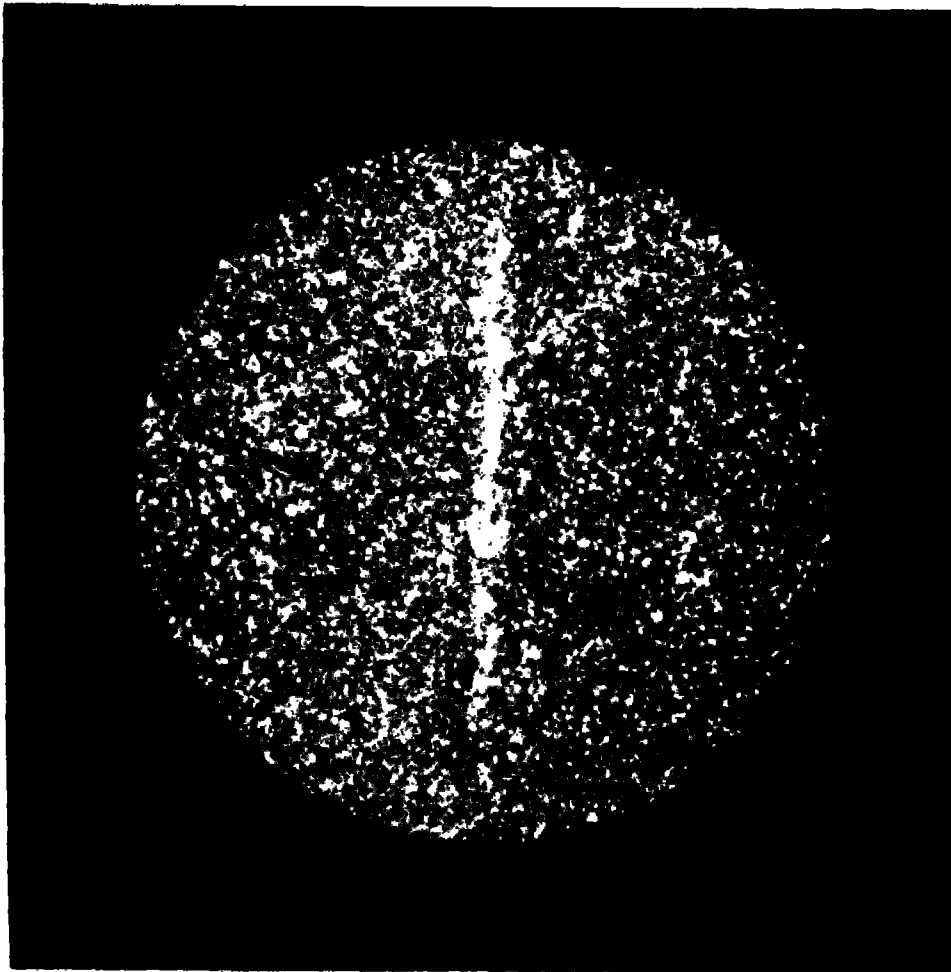


Fig. 3

## Static test at a rotating target neutron source

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$\sim 10^{11}$  neutrons at  
the source

Source to cathode  
distance 1.2m

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The image is attributed to the  $U^{238}$  cathode